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Sensitive Transistorized Field Strength Meter

Part 2: Construction, Calibration and Use

By the Engineering Department, Aerovox Corporation

IN Part I of this series, the circuit of the sensitive field strength meter was given and its features discussed. For convenience, the circuit diagram and parts list are repeated in Fig. 1. R-f voltage developed across a tuned circuit connected to an antenna or other source is applied to a germanium diode X1; the rectified current through the base-emitter circuit of the transistor, which is the load on the diode, is amplified by the transistor and indicated on the microammeter. Frequency range switching is provided by S1, and the three sensitivities are provided by S2, which switches shunts across the meter. Battery B2 provides balance current in the meter, so the transistor can be biased for best weak-signal sensitivity.

In this Part, physical factors in construction, calibration and the application of the instrument are discussed.

Layout

The physical details of layout and wiring are shown in the rear view of Fig. 2, and the front view of Fig. 3. To minimize r-f currents in the case, a sheet of flashing copper forms the ground return path between the variable capacitor C2 and the switch S1. The first section of the coil is a straight piece of wire between the stator connection of the capacitor and the first tap of the switch. With the 35-uuf variable capacitor used, the highest frequency attainable in the resonant circuit is between 120 and 200 mc, depending on the input load. With special balanced arrangements, and a smaller capacitor, higher frequencies could be reached, but in this case the object was to obtain good operation over as wide a range of frequency as possible, thus the larger capacitor.

The tuned circuit is the only one which is at all critical, and all other wiring is straightforward and locations of the parts can be varied to suit. Of course, the usual care is in order in soldering both the crystal diode and the transistor, so these will not be damaged by heat. Use of the needle-nosed pliers as a "heat sink" is an important precaution in making connections to both of these components.

Because of the balance arrangement between currents from the two batteries previously discussed, the batteries should be connected last, and the switch S3 should be checked to make sure it is in "off" position before the battery connections are made.

Batteries

Although mercury cells are ideally suited to use in this instrument, ordinary "pen-light" dry batteries can also be used, with somewhat shorter life expectancy. Because mercury cells are light and compact, they keep the weight of the instrument down, and allow space to spare in the case, for other extra features which the constructor might want to add to the circuit. With mercury cells of medium size, the current drain of the instrument is so low that practically shelf life (several years) can be expected. In fact, were it not for the balance arrangement which requires that some method of removing both batteries at once be removed for circuit changes or adjustments, the instrument could probably be left on indefinitely with almost full shelf life from the batteries! The development model uses "pen-light" cells, and has given about a hundred hours of service with no sign of battery deterioration.

Use With an Antenna

The instrument works well with a vertical rod or "whip" antenna from several inches to 4 feet long, depending upon frequency and sensitivity desired. At the higher frequencies,

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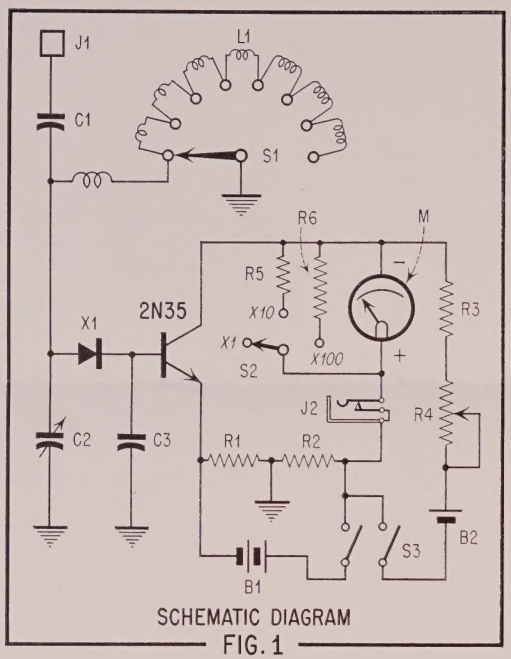


SCHEMATIC DIAGRAM

FIG. 1

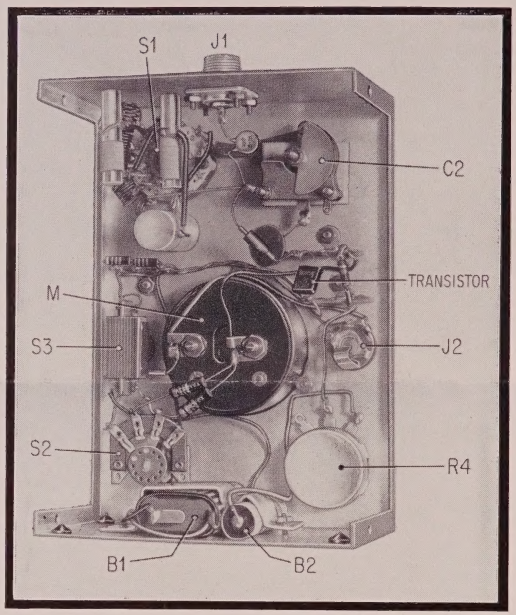


FIG. 2, REAR VIEW SHOWING LAYOUT AND PLACEMENT OF COMPONENTS

sensitivity will of course vary with how near resonance the antenna is made. The input circuit of Fig. 1 is for high impedance, so a half-wave antenna would produce greatest pick-up, while a quarter-wave antenna would give relatively poor sensitivity. In Part I, an alternative low-impedance input circuit was suggested, with which a quarter-wave antenna would be appropriate. The low-impedance arrangement also allows connection of a transmission line, for connection to a remote antenna or other signal source to be measured. At lower frequencies (below about 70 mc) resonant rods start to become cumbersome, and something less than a quarter-wavelength is more convenient. The lack of resonance is partially overcome by the increase of aperature due to the larger antenna, as compared to the resonant whips for considerably higher frequencies. Within a hundred feet or so of the antennas of transmitters of even moderately low power (50 watts output) the model has been found to give strong indications with only an inch or two of antenna.

When signals of different but closely-spaced frequencies are to be measured, a non-resonant antenna is usually desirable, because pickup on a resonant antenna varies considerably in the vicinity of resonance frequency.

PARTS LIST

C1 – 0.001 μf disc ceramic (Aerovox type BPD)
C2 – 35 μμf maximum (Cardwell PL6003)
C3 – 0.005 μf disc ceramic (Aerovox type BPD)

J1 – Coaxial connector (Amphenol type 83-1R)
J2 – Phone jack, closed circuit (ICA type 1871)

R1 – 2700 ohms ±5% ½ W (Aerovox type 1097)
R2 – 47 K ohms ±5% ½ W (" " ")
R3 – 1000 ohms ±10% ½ W (" " ")
R4 – 5000 ohms, WW control (Clarostat type A43-5000)
R5 – Shunt to provide 100/1 multiplication *(See text)*
R6 – Shunt to provide 10/1 multiplication *(See text)*

S1 – SP, 8 pos., shorting, steatite insulation (Centralab PA-2000)
S2 – SP, 3 pos., shorting (Centralab type 1461)
S3 – Toggle switch, D.P.S.T.

Transistor – NPN junction audio type (Sylvania 2N35)

X1 – Germanium diode, type G7A

B1 – 3 volts, "pen-light" cells or mercury type
B2 – 1.5 volts, same as B1

Case, aluminum, 7" X 5" X 3" (Bud type CU-2108)

L1 – Coils wound to resonate over desired frequency ranges
M – Microammeter, full scale reading from 100 to 1000 μa

In the field-testing of the model, a number of checks were made with a 2-meter transmitter, operating on about 147 mc. The transmitter was operated at about 15 watts input to the plate circuit of the final, which was coupled to 5 half-waves in phase, average height of the antenna being about 20 feet. From this transmitter, conveniently-readable meter deflections were obtained with the model at ground level as far away as a quarter of a mile from the transmitting antenna. A 38-inch rod was used with the instrument.

It was found that a good practical antenna for the instrument can be made by cutting off the last two sections of an automobile whip antenna, and soldering the base end into an 83-1SP type coaxial plug. The latter then fits into the connector on the

FIG. 3, FRONT VIEW

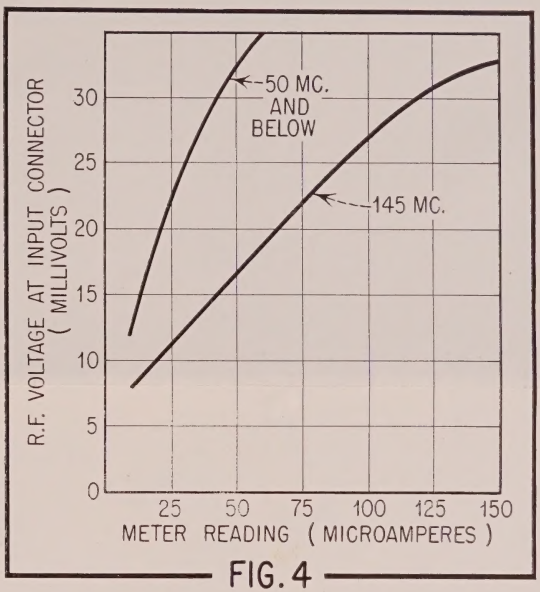


FIG. 4

top of the instrument and supports the whip. A variation of whip length for different frequencies and sensitivities is then possible.

The length of antenna employed influences to some extent the frequency range of the instrument, because of the reactance it adds to the tuned circuit. The frequency calibration on the panel of the model illustrated was made with a 1-foot rod antenna, with which the highest resonant frequency is about 140 mc. However, with other antenna lengths, the instrument can be tuned to frequencies as high as 200 mc. With other types of resonant circuit, the high frequency limit can be even further extended, especially if band switching is eliminated and the antenna coupling method changed to the low-impedance arrangement described in Part I.

Calibration

The easiest way to calibrate the instrument is in terms of millivolts input to the antenna connector. Of course, this gives no information as to the relation between field strength and input voltage, which depends upon the type of antenna and the frequency. However, it does give an idea as to the relation between different readings with a given antenna at a given frequency. Charts can be made up, correlating meter reading to microvolts input for each sensitivity position. A graph giving this kind of relation at two frequencies for the model is shown in Fig. 4. In the model, sensitivity at frequencies above 50 mc is somewhat greater than at lower frequencies, due to the more favorable impedance relationships on ranges in which the inductance is small. Readings were taken with a laboratory type signal generator of 50-ohm source impedance (Measurements Model 80 with pad.) Probably, the impedance of the generator was shunting the diode and the high-impedance sensitivity may be somewhat better, the imput impedance of the grounded-emitter transistor circuit being roughly 2,000 ohms.

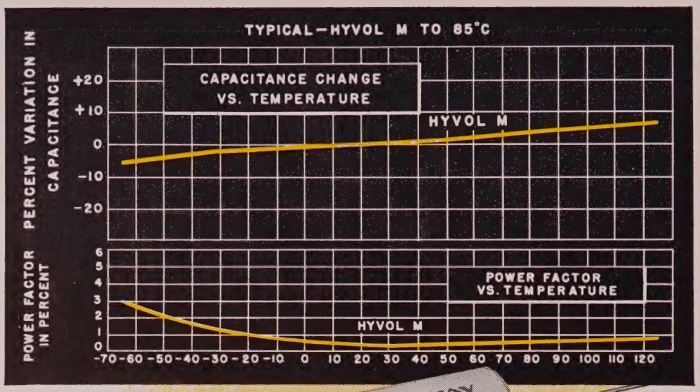
If a calibration is desired in terms of actual field strength a reliable standard must be obtained, and the calibration accomplished through comparison. A standard antenna (or set of antennas) must be chosen, and all of any given set of readings taken with the same one. At the higher frequencies, this is a very difficult business, because reflections, movement of the body in the vicinity, etc., cause wide variations of readings. Such calibration should not be attempted without special equipment designed for the purpose.

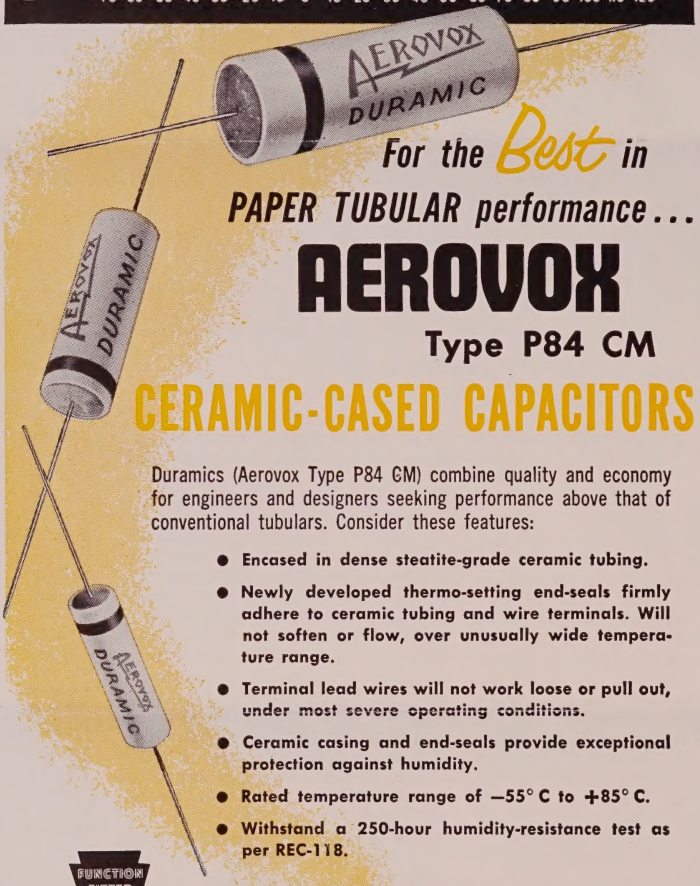
Variations

The circuit and construction details given here are those of an actual model which is now giving good service. However, undoubtedly the experienced engineer will find many ways to vary the circuit to suit his own special requirements. For example, the tuned circuit may be modified to tune to higher frequencies and perhaps cover only one or two ranges. As previously explained, addition of another section on the switch S1 will allow the use of low-impedance coupling links and greater versatility as far as impedance relations are concerned.

If relatively weak signals are not to be measured, the bucking circuit R3-R4-B2 can be removed. Then the voltage divider R1-R2 must also be removed and the negative terminal of the battery B1 grounded. This reduces the input bias to zero, and there is then approximately zero collector-emitter current and meter balancing is not necessary. The sensitivity for very weak signals is thereby greatly reduced, but the sensitivity for moderate and strong signals is not as much affected.

The transistor is a temperature-sensitive device, so a noticeable difference in zero adjustment will be encountered if the instrument is used with widely-varying ambients. However, R4 should be of sufficient resistance to balance the meter for all but great extremes of temperature.





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